JET AIRCRAFT FAN CASE CONTAINMENT DESIGN

FIELD OF THE INVENTION

The present invention is directed to an improved jet aircraft fan case containment system.

BACKGROUND OF THE INVENTION

Modern aircraft are often powered by a propulsion system that includes a gas turbine engine housed within an aerodynamic streamlined nacelle. The major engine components include a fan section comprising a rotatable hub, an array of fan blades projecting radially from the hub and a fan casing encircling the blade array of fan blades. One of the functions of the fan casing is to contain or capture a blade, or a blade fragment, if it should become separated from the hub.

For small diameter engines, adequate containment capability is generally achieved with a metallic case thick enough to resist penetration by blade fragments. For large diameter engines, a metallic case thick enough to resist penetration is prohibitively heavy as the size of potential projectiles in the form of blades or blade fragments become larger. Therefore, it is customary for manufacturers of large diameter engines to employ a fabric wrapped containment system comprising a light weight, high strength ballistic fabric such as fabric composed of aromatic polyamide fiber of extremely high tensile strength and greater resistance of elongation than steel wrapped in multiple layers around a relatively thin, penetration susceptible support case. Such aromatic polyamide fiber has a high energy-absorption property, which makes it useful for containing projectiles, such as aircraft engine fan blades or blade fragments. One well-known type of aromatic polyamide fiber is KEVLAR® (a trademark of E.I. DuPont de Nemours & Company). In operation, a separated blade or blade fragment penetrates the support case and strikes the fabric. The fabric deflects radially, however at least some of the fabric layers remain intact to capture and contain the fragment. The casings for such engines are large, requiring a significant quantity of expensive KEVLAR®.

The customary construction of smaller diameter engines employs stiffening ribs annularly around the exterior wall of the fan case. In operation, a separated blade fragment will not penetrate the casing and will be contained within the casing boundaries. However, the use of aluminum alloy as the sole component of the fan casing results in a casing that is rather heavy.

Such containment systems add considerable weight to both types of engines. Therefore it is desirable to utilize materials that reduce the weight of the case without reducing the strength of the case, and that replace expensive KEVLAR® with less expensive material.

SUMMARY OF THE INVENTION

Recent improvements in polyurethane technology have improved polyurethane's ability to withstand temperatures over 250° F. without a decrease in mechanical properties. Additionally, polyurethane has a very high strain to failure ratio at 400%. There are some benefits as to the weight of a certain volume of polyurethane when compared to aluminum or steel, since polyurethane is 55% lighter than aluminum and 80% lighter than steel. Thus, a preselected thickness of polyurethane can provide the same energy-absorbing capabilities as these metals at a significant reduction in weight.

Briefly stated, one embodiment of the present invention provides a fan casing which includes a penetrable first

covering wrapped around an impact zone of a support case, a second support covering also wrapped around the impact zone of the support case, a third support covering wrapped around the support case but axially offset from the impact zone, and a fourth penetration-resistant containment covering wrapped around both the first penetrable covering and the second and third support coverings The fourth penetration-resistant containment covering includes at least a polyurethane portion and has high energy absorbing capabilities. The polyurethane can be wrapped with KEVLAR®. However, because of the energy-absorbing capabilities of the polyurethane, the amount of KEVLAR® required to provide containment can be reduced. In the event that a high energy blade fragment ruptures the support case, the penetrable covering and the second and third support coverings, the penetration-resistant covering intercepts the deformed fragment, confining it to a predetermined radial envelope. The relatively high ability of polyurethane to absorb energy in comparison to a similar weight of aluminum or steel decreases the magnitude of the stress that is transmitted along the fan case. In all situations, the fan case of a jet engine must be designed to be able to contain an engine fan blade in the event of a blade-out failure. The use of polyurethane as a component of the fan case will also result in a reduction in the overall weight of the fan cases, as a lighter material can be used to provide the required containment capability for the fan case.

A second embodiment of the present invention provides a metal case with a reduced wall thickness, with a layer of polyurethane cast on the outer surface of the metal case. The layer or layers of KEVLAR® may optionally be wrapped over the cast polyurethane.

In all embodiments, the casing walls located adjacent to the blade tips are subjected to internal pressure pulses traveling with the rotating blades. In addition, low integral order rotor per revolution and bearing passing frequency excitations are transmitted to the casing through casing joints within the frames. The addition of polyurethane to the fan case improves damping capability, thereby improving the vibrational characteristics of the case. One advantage of the present invention is a reduction in the weight of the fan case containment structure, without a reduction in the ability of the fan casing containment structure to contain or capture fan blades or blade fragments. Such a reduction in weight will increase the fuel efficiency of engines that utilize fan blade containment structures.

Another advantage of the present invention is a reduction in the forces that are transmitted through the fan case containment structure, which reduces the overall fatigue of the structure since the overall stress and strain on the component parts is reduced. Such a reduction in the transmitted forces will allow the engine to be operated for longer periods of time without requiring repairs.

Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view, in partial cross-section, of a forward portion of a fan jet engine including a fan casing according to one embodiment of the present invention.

FIG. **2** is a second side view, in partial cross-section, of a forward portion of a second fan jet engine including a fan casing structure known to the art.

FIG. **3** is a third side view, in partial cross-section, of a forward portion of a third fan jet engine including a fan casing structure according to a second embodiment of the present invention.